

King County Lake Monitoring Report



Volunteer Lake Monitoring Results for Water Year 2004



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Department of Natural Resources and Parks
Water and Land Resources Division

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April 2006



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Lake Stewardship Program

Introduction, Methods, and Bibliography



Contributors

We would like to thank all the King County staff involved in the administration, training, volunteer coordination, and equipment management of the Volunteer Lake Monitoring Program. Staff efforts included data verification, reduction and management, laboratory analysis, quality assurance and control, technical writing, and report layout and production. The following individuals have contributed significantly to the Volunteer Lake Monitoring Program and the production of this report:

Data analysis and charts:

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Purpose of Report

This report is the tenth in a series that summarizes data collected by volunteer lake monitors annually. This volume covers water year 2004 (October 2003 through September 2004), extending through October 2004 for water quality measurements. The intent is to provide citizens, scientists, lake managers, jurisdictions, and other interested individuals with current information on King County lake water quality and physical conditions for lakes monitored by participating citizens.

For many lakes, these data represent the only reliable source of information for assessing current water quality and addressing questions regarding the characteristics of a particular lake. The information in this report can help to guide lake protection and stewardship activities in King County and can be used to plan further work to address specific questions about a lake's conditions.

Report Layout

The format of the report is in three sections, which will be available separately for downloading on the Lake Stewardship Web site at <http://dnr.metrokc.gov/wlr/waterres/smlakes/reports.htm>.

This section, Section One, unites the introduction and methods chapter from earlier reports, but omits the extensive discussion of processes in lakes and human impacts that was repeated annually. The information can be found in the 2000 – 2002 reports which are also available on-line at the same site.

Section Two contains annual and comparative climatic information, as well as the regionally-based reporting on the lakes, including analyses and comparisons.

Section Three combines the individual lake reports with the tables of data formerly found in Appendices A and B, divided into subsections for each individual lake. All of the data tables, charts, and discussion for each lake will be available for downloading as stand-alone .pdf files. The chapter on freshwater algae has been omitted, since it also was repeated annually and can be found in the 2002 annual report on-line.

Geographic and bathymetric maps can be found as stand-alone documents in the 2003 report on-line.

Introduction, Methods, and Bibliography

LAKE	LEVEL	VOLUNTEERS IN 2004
Alice	Level II	Jenny Emsky
Allen	Level I & II	David & Betty Burton
Ames	Level I & II	Bob Young
Angle	Level I	Diane & Alden Chace
Angle	Level II	Edward & Jeannie Montry
Beaver-1	Level II	Donna Carlson
Beaver-2	Level I	Ray Petit
Beaver-2	Level I	Al Jokisch
Beaver-2	Level II	Larry Miller
Bitter	Level II	Tom & Danae Hollowed
Boren	Level I	Mary Alice & Eric Root
Boren	Level II	Ray Clark
Burien	Level II	Steve Locher
Clark	Level II	Matt Knox
Cottage	Level I & II	Ed Grubbs
Cottage	Level I & II	Matt McCain
Cottage	Level II	Ann Whitney
Desire	Level I	Ed & Min Merrill
Desire	Level II	Jan Falkenhagen
Desire	Level II	Jim & Betsy Locatelli
Echo (Shoreline)	Level I	Angelique Neketas
Echo (Shoreline)	Level I	Georgeanne Smith
Echo (Shoreline)	Level II	Barbara Guthrie
Echo (Shoreline)	Level II	Anne Guthrie
Echo (Snoqualmie)	Level I & II	Shana Kalenius
Fenwick	Level II	Matt Knox
Fivemile	Level II	Janet Gillies
Francis	Level I & II	Brian Moriarty
Geneva	Level I	Sue Yunker-Jones & Tom Jones
Geneva	Level II	Laura Stiles & Bruce Harpham
Grass	Level I & II	Kathryn Howard
Haller	Level I & II	Rud Okeson
Haller	Level I & II	Rick & Susan Ehle
Haller	Level I	Barbara Gross
Horseshoe	Level I	Barbara Rush
Horseshoe	Level I & II	Eric Olsgaard
Jones	Level II	Dale & Linda Anson
Joy	Level I & II	Bob & Sam Charles
Kathleen	Level I & II	Keith Lanan
Kathleen	Level I	Kurt Tokita
Killarney	Level I	Kenna Patrick
Killarney	Level II	Craig Rice
Killarney (north)	Level II	Gerri & Bill Baldwin
Killarney (north)	Level II	Cheryl Burner
Langlois	Level II	Denise Mahnke
Leota	Level I & II	David Mangels
Leota	Level I & II	Rick Sampson

Table 1-1. Volunteer Monitors Sampled 53 Lakes

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LAKE	LEVEL	VOLUNTEERS IN 2004
Lucerne	Level II	Milo Dullum
Marcel	Level I & II	Chuck Willis
Marcel	Level I & II	Andy Wones
Margaret	Level I & II	Douglas Johnston
Margaret	Level I & II	Meredith Mitchell
McDonald	Level I	Suzanne & Jeff Lowry
McDonald	Level II	Burt & Marty Sweet
Meridian	Level I	Kathe Dizard
Meridian	Level II	Al Flores
Mirror	Level I & II	Bob Roper
Morton	Level I & II	Paul & Laura Mueller
Morton	Level I	Dick Balash
Morton	Level I	Marty & Sandy Landers
Neilson (Holm)	Level I & II	Kevin & Kurtis Schultz
North	Level I & II	Debra Hansen
North	Level I & II	Wendy Honey
North	Level I & II	Robin & Tim Cook
North	Level I & II	Tom Jovanovich
North	Level I & II	Brett & Diane Radford
North	Level I	Chuck Gibson
Paradise	Level I & II	Shirley Egerdahl
Peterson Pond	Level I	Karen Tomfohrde
Peterson Pond	Level I & II	C.K. Panchapagesan
Pine	Level I & II	Kate Bradley
Pipe	Lake I	Ralph Beede
Pipe	Level II	Bob Brenner
Sawyer	Level I & II	Glenn Ross
Sawyer	Level I	John Davies
Shadow	Level I	Billy Aliment
Shadow	Level II	Jake Finlinson
Shady	Level I & II	Ray Konecke
Spring	Level I	Bob Keller
Spring	Level II	Caren Adams
Star	Level II	Mark Baughman
Steel	Level I & II	Susan Pearson
Trout	Level I & II	Brenda & Jim Sherwood
Twelve	Level I & II	Cathy & Dean Voelker
Twelve	Level I & II	Jan DeLacy
Walker	Level I & II	Dave & Monica Higgins
Welcome	Level I & II	Dave Hadley
Wilderness	Level I & II	Ray Petit
Yellow	Level I & II	Steve Paoletti
Yellow	Level I & II	Meg Pearson
Yellow	Level I & II	Karen May & Lyle Whitcomb
Yellow	Level I & II	Shelley Dahlgren

Table 1-1. Volunteer Monitors Sampled 53 Lakes (continued)

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Why Monitor?

The specific data that is collected on lakes varies from one program to another, depending on the chosen objectives of the program. For the King County Lake Stewardship Program, the overarching objectives of data collection have included:

- (1) gathering baseline data and assessing long-term trends, particularly for lakes that do not have any other organized assessment efforts focused on them;
- (2) defining seasonal and water column variability over time to establish normal ranges;
- (3) identifying potential problems, proposing possible management solutions and alternatives, or pinpointing additional studies to be made to accomplish such goals; and
- (4) educating lake residents, lake users, and policy makers regarding lake water quality and its protection; and (5) providing a solid, reliable, cost-effective foundation of knowledge that can be used for long-term stewardship of King County lakes.

Every lake is a unique body of water, reflecting the characteristics and hydrology of the watershed. Water quality is affected by the sources and relative quantity of water inflows, including the amounts and types of nutrients originating from the watershed, in particular nitrogen and phosphorus. For example, when the surface area of a lake represents a relatively large percentage of the total watershed, much of the precipitation falling in the basin goes directly into the lake, not passing first through soils, wetlands or constructed drainage systems. Thus, in this case relatively pure rain water makes up a significant proportion of the total input to the lake. In other cases where direct precipitation makes up a smaller proportion of the water input, land use practices throughout the watershed become very important influences on conditions within lakes.

Water chemistry and physical characteristics in lakes vary seasonally as well as by depth at certain times of the year. The most dynamic period for lakes is during the “growing season” of mid-spring through early autumn when lake dwelling organisms are most active. To maximize information obtained for the effort, the Volunteer Monitoring Program offers two different programs: Level I monitors collect data all year on precipitation, lake level, surface water temperature, and water clarity. Level II monitors measure temperature and clarity, and also collect samples for water chemistry through most of the growing season (generally May through October). Level II sampling also coincides with the primary recreational period for lakes in the Pacific Northwest.

The Program has focused on the monitoring of water chemistry in the upper water layers during the growing season in order to characterize lake trophic state. However, during the summer in most lakes, water chemistry and temperature vary with depth. As funds have allowed, additional sampling has been performed to characterize the water chemistry of the deeper lake layers. This vertical sampling has provided data that is useful in understanding the general nutrient cycling and water column relationships in individual lakes. On two dates in water year 2004, Level II samples were collected from the surface, middle, and one meter above the bottom in the deepest part of the lake to define changes found in the vertical profiles of the parameters.

Program Summary and Outlook

The 2004 monitoring program, which ran from October 2003 through October 2004, represented the ongoing effort by King County to expand the information available on the smaller lakes within its boundaries. The program attempted to maximize limited resources amid the changing jurisdictions within King County, while the staff remained committed to making the most of the volunteer monitors’ time and effort. Changes may

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continue to occur for both the methods of collection and reporting as adjustments are made in response to volunteer requests and staff observations. Some parameters may be discontinued, while others may be added to the program if the information gained is considered to be important in assessing the condition of the lakes.

The Lake Stewardship Program's Web site, <http://dnr.metrokc.gov/wlr/waterres/smlakes>, continues to feature lake management information, as well as electronic copies of many of our publications. In addition, the site highlights the efforts of our volunteer monitors and provides information to people interested in joining the data collection program.

The Lake Stewardship Program staff provides volunteers with technical assistance and answers to questions relating to limnological processes and conditions found at specific lakes. Please give us a call with concerns and feedback. We always enjoy hearing from you.

Methods

Volunteer monitors (Table 1-1, see pages 2-3) sampled 53 lakes for the Lake Stewardship Program in water year 2004. The lakes sampled were mostly located in the western third of the county, largely coinciding with current residential development (Figure 1-1). They ranged in surface area from 7 acres to 279 acres and in maximum depth from 7 feet to 98 feet. These lakes spanned all trophic classifications and degrees of urbanization in their watersheds.

The Lake Stewardship Volunteer Monitoring Program is split into two levels of data collection, known as Level I and Level II. Throughout the year, the Level I participants measure precipitation, lake level, surface water temperature, and clarity (Secchi depth). The Level II participants collect water samples for water quality analysis, while also measuring water temperature and clarity, from the end of April through October.

Level I Data Collection

Level I data collection occurs daily and weekly, and is compiled by the Water Year, which begins with October and ends in September. The water year differs from the calendar year because it is based on annual precipitation and hydrologic patterns.

In water year 2004, volunteers at 20 lakes participated in the Level I program for most or all of the water year. For several other lakes, volunteers were not able to complete this commitment or were recruited later in the year, so the data are incomplete.

Lake level and precipitation measurements were recorded daily by volunteers. Lake level was recorded by reading a gauge (a porcelain-glazed aluminum metric ruler) attached permanently to a rigid dock or other fixed structure in the lake, usually near the volunteer's home. Often the meter sticks have not been calibrated to elevation, so the measurements are relative to the stick position rather than sea level. Precipitation was collected in a plastic rain gauge installed in an area exposed to direct rainfall and away from overhanging objects such as trees or buildings.

Water clarity (Secchi depth) and surface water temperature were measured weekly. Secchi depth generally was measured over the lake's deepest point (Wolcott 1961, USGS 1976). The method involves lowering an eight-inch disk painted with alternating black and white quadrants over the shaded side of the boat until the disk disappears from view, then lifting it until it reappears again. The depths at each point are noted and, if different, are averaged.

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Volunteers measured water temperature at the same location as Secchi depth. The method called for submerging a Celsius thermometer in the water to about one meter below the water surface for two minutes, then bringing it to the surface and reading the temperature to the nearest 0.5 degrees. Further details on Level I volunteer monitoring sampling methods are supplied in the *Lake Stewardship Program Volunteer Lake Monitor 2004 Sampling Manual* (King County 2004), which can be found in the volunteer monitoring section of the Lake Stewardship Web site at: <http://dnr.metrokc.gov/wlr/waterres/smlakes/monitor.htm#manual>.

Daily data are transformed either by summation (precipitation) or by averaging (water levels) into weekly values when all or nearly all daily values were measured, while the parameters measured weekly are reported directly. All original data are available upon request to King County Water and Land Resources Division.

Level II Data Collection

Level II volunteer monitoring activities occurred every two weeks from late April through October on a pre-determined schedule. Water samples were collected at one meter depth on every sampling date, and volunteers also collected deeper samples twice during the period, usually at mid-depth as well as at one meter from the lake bottom.

In water year 2004, 52 lakes had volunteers who participated in the Level II program. For most lakes, volunteers were able to collect data for the entire period (May through October). Gaps and anomalies are noted by lake in Section three. A flow chart of the entire sampling and data production process shows how samples are treated after collection (Figure 1-2).

Volunteers anchored at a specified location, generally over the lake's deepest point. For each date, volunteers recorded the time and weather, as well as making observations on unusual conditions or activities on the lake.

Secchi depth was measured using the same methods as described for Level I. Water samples were collected using a Van Dorn vertical water sampler at one meter depth. Temperature was read from a thermometer installed inside the sampler, after which water was saved in special containers for further analysis, generally for total phosphorus, total nitrogen, chlorophyll *a*, and phytoplankton.

On the two dates when vertical profiles were sampled, samples were taken at one meter, mid-depth, and one meter from the lake bottom. Temperature was measured at each depth using the thermometer mounted inside the sampler, and water samples for total phosphorus and total nitrogen were collected at all three depths. Chlorophyll *a* and phytoplankton analyses were generally collected for the one meter and mid-depth samples only, but there were some exceptions in cases when the bathymetry or history of the lake suggested that large deep water phytoplankton concentrations might occur.

The water samples were analyzed at the EPA approved King County Environmental Laboratory for total phosphorus, total nitrogen, chlorophyll *a*, and pheophytin *a* using standard protocols, as well as quality assurance and quality control procedures. Phytoplankton (algae) identifications and qualitative estimates were carried out by a combination of a qualified consultant and a King County staff person with extensive phytoplankton experience .

Physical and chemical values for each date are detailed in Section Three. Phytoplankton data for individual dates are available upon request. Further details on Level II volunteer monitoring sampling methods are described in the *Lake Stewardship Program Volunteer Lake Monitor 2002 Sampling Manual* (King County 2004).

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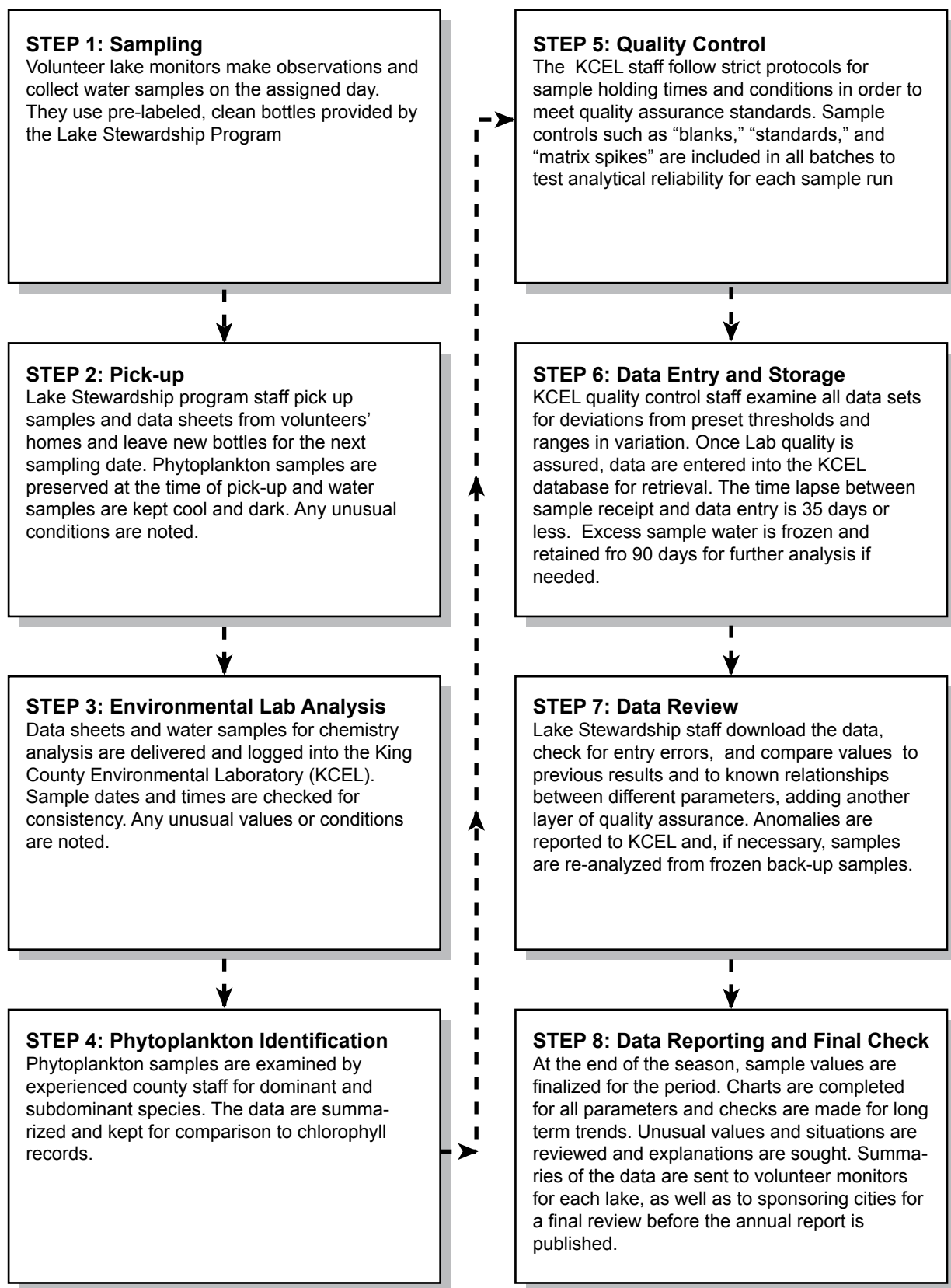


Figure 1-2. How lake samples are collected and processed

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Other parameters

While on the lake, many monitors also rated algae and particle concentrations in 2004, and this is reported in the individual lake tables of Section three under Algae Observations. The Secchi disc was lowered 6" under the water surface and a rough estimate of particles visible in the two white sections was made. At 6" depth, the two sections correspond to a total of 2 liters of water volume. A zero corresponded to no particulate algae seen in the water, while a 1 meant less than 10, a 2 between 10 and 100, and 3 corresponded to greater than 100. This exercise was not meant to be a quantitative measurement, but rather as a general qualitative indication of how many particles were present at a particular time, to be kept in mind when evaluating Secchi transparency results.

Some volunteers also kept track of the numbers of Canada geese found on their lakes. They had two methods from which to choose, but needed to stay consistently with their chosen method in order to make comparisons reliable. They could either keep track daily of the maximum number of geese that were seen on the lake at any one time during the day, or they could keep track of the maximum seen at any one time on a weekly basis. There was no summation of geese seen over any periods because of the possibility of counting the same individuals more than once.

Data Analysis

Minimum, maximum, and average values for temperature and Secchi depth were determined for the Level I volunteer monitoring data. Annual lake level range and total precipitation were determined for each participating lake with complete data sets. The data are illustrated in charts for each individual lake (Section 3).

For Level II water quality measurements, the minimum, maximum, and average values were determined for the sampling period. The values found throughout the sample season are charted for each lake, with total nitrogen

and total phosphorus on the same chart for comparison (Section Three).

The Trophic State Index, or TSI, (Carlson 1977) was calculated for Level II volunteer monitoring data. TSI values are derived from a regression derived by comparing values of a parameter such as total phosphorus, chlorophyll *a* or Secchi transparency to the algal bio-volume of a suite of lakes and then transformed into a number on a scale of 0 to 100, based on the relationship found. This scale can be used to compare water quality over time and between lakes (see discussion in Section Two-C and data for individual lakes in Section Three).

The nitrogen to phosphorus ratios (N:P) were also calculated since, if nutrient limitation of algal growth is likely to be occurring, the nitrogen to phosphorus ratio may be used to identify the nutrient that is in shortest supply. Generally lakes with an N:P ratio of less than 20 may be experiencing limitations by both nitrogen and phosphorus at times during the growing season. The results of these analyses for the lakes are presented in both Section Two and Section 3.

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